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LIV.—Asterias rubens *and the British Species allied thereto.*

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[Plates XIV. & XV.]

The definition of Starfishes in terms which shall, on the one hand, be intelligible because brief, and on the other accurate because complete, is perhaps as difficult an undertaking as any in systematic zoology. In some cases the amount of variation is so extraordinary that it is necessary to preface any definitions which one may be so presumptuous as to offer with some words of explanation. *Asterias rubens* is a case in point; it is, indeed, a subject which has already been treated of by many writers, and I will therefore be as concise as I know how. The reader may be assured that what is here put before him, even if it appear to him prolix, is but a summary of facts slowly acquired and long looked at from various points of view.

I shall, I am afraid, be found to differ from the conclusions on different points to which Canon Norman on the one hand or Mr. Sladen on the other have or would have arrived; but the discrimination of species is after all a matter of individual judgment—or the lack of it.

It will be remembered that a number of naturalists have

distinguished the "violet crossfish" from the "common crossfish;" some have asserted that they live together, others that they are found apart; some, more exact, have stated where they have found them living together and where they have found them apart; authors have varied in the extent to which they believed them to be allied, from Müller and Troschel, who on p. 11 of their famous 'System der Asteriden,' regarded them as distinct, and on p. 126 in the "Nachträge" to the same work regarded them as "eins und dasselbe," to the latest reformator systematis, who cannot bring himself to put them in the same subgeneric division of "*Asterias*."

The differences of opinion which have existed will be easily understood by one who will take either a named or an unnamed set of some dozen specimens from almost any locality, so great are the variations of spinulation that may be detected.

Forbes distinguished the two, and gave figures to show the differences in the form of their ambulacra (Brit. Starf. p. 99); and the just weight of his authority has caused students of the British fauna to keep the two forms apart.

Without entering into full historical details on this point, there are some more recent authorities whose views must be noticed and discussed.

In a very valuable paper published in this Journal in 1865 the Rev. Dr. Norman writes *:—"The species of *Asterias*, both British and foreign, allied to *A. rubens* are extremely difficult. We are unable to make up our minds whether we have only one very variable form or many species. We have described the two species distinguished by Forbes, *A. violacea* and *A. hispida*, but for the present feel compelled to reserve giving a positive opinion with respect to the value of their distinctive characters. . . . . We have other closely allied forms in our seas, which scarcely fall under the description of any species here described."

Prof. Perrier in 1875 wrote †:—"Ainsi l'examen de tous ces échantillons témoigne simplement du polymorphisme et de la grande extension géographique de l'*Asterias rubens*; mais les types divers que l'on peut observer et qu'on serait d'abord tenté de separer sont unis par tant de formes intermédiaires, qu'il devient bientôt impossible, quand on a beaucoup d'individus sous la main, d'établir aucune division tranchée. Je ne saurais donc jusqu'ici admettre l'*Asterias violacea* comme espèce distincte."

* Ann. & Mag. Nat. Hist. xv. 1865, p. 129.
† Arch. Zool. gén. et expér. iv. p. 314.

Very careful attention was paid to this question by the late Mr. George Hodge, and by the kindness of the authorities of the Museum of the Natural History Society at Newcastle-upon-Tyne I have been enabled to inspect for myself the specimens on which he founded his conclusions. The most important point is that he and Canon Norman agree generally as to what they call *A. violacea*, as I am able to testify from specimens which Dr. Norman has kindly lent me.

Under the head of *Asterias rubens* Mr. Hodge (Trans. North. & Durham. iv. (1872) p. 137) writes:—

"This and the following species are united by some authors: I think, however, we have sufficient grounds for separating them, their habitat and the form and character of the spines being quite distinct. The genus is altogether a puzzling one, and one in which it is very difficult to set up distinctive characters by which readily to distinguish one species from another, excepting in those examples which there is no mistaking. *A. rubens* runs off into several variations; but whether they are really distinct species or mere varieties it is difficult to decide.

"I may, however, state I have three strongly marked varieties, in addition to what I take to be the typical form, viz.:—

"1. *Asterias rubens*, var. *hispida*.—A small, squat, neat form, of which I have specimens dredged in deep water off Northumberland and Durham. They appear mature individuals, although they are only about half an inch across.

"2. *A. rubens*, var. *attenuata*.—A slender smooth form, sparingly furnished with spines, very distinct in character, obtained by dredging in Berwick Bay, 30 to 45 fathoms.

"3. *A. rubens*, var. *gigantea*.—A very large coarse species, occasionally brought in by the fishing-lines from deep water. It sometimes attains the enormous size of 14 inches, Mr. G. S. Brady having a specimen of this size. Those that I have obtained are two to three inches smaller. It is thickly beset with spines; the pedicellariæ are very numerous. In substance it is rather 'flabby,' and unless care is used when handling it in a living state, its rays are liable to break off at their junction with the disc; at this part the rays are rather restricted."

On this it may be remarked that a naturalist who has easy access to fresh specimens of what has been called *A. hispida* would be doing a service if he would determine whether these small squat forms do contain mature ova and spermatozoa. I have myself been constantly on the look out for larger specimens which might be supposed to be the adults of *A.*

hispida, and have only once seen a specimen which I felt inclined to regard as such.

Among the many interesting specimens of Asterida which the British Museum owes to Mr. John Murray's dredgings on the west coast of Scotland there is one remarkable form which justifies the acceptation of Mr. Hodge's variety *attenuata*, and I am inclined to think the abnormal 'Knight Errant' specimen referred to by Mr. Sladen on p. 573 of his 'Challenger' Report might be placed in the same category.

Starfishes grow to such considerable size that there does not appear to be any justification for the "var. *gigantea*."

With regard to *A. violacea* Mr. Hodge says:—

"A very common species with us, so far as I know. On the Durham coast it is only found between tide-marks, whilst the former species (*A. rubens*) is seldom if ever taken under similar conditions. It is readily distinguished from the preceding by the bluntness of its spines, especially on the dorsal aspect, where they are mostly rounded at their summits, or in some cases one would almost say 'truncate.' In *A. rubens* the spines are (I believe) invariably pointed. Other distinct characters are apparent on examining specimens of each side by side; the general appearance of each is quite distinct, as is their habitat. Here (Seaham) I have never to my knowledge taken this species at sea, neither have I obtained *A. rubens* living within tide-marks."

If you take a few selected specimens you may show the justice of Mr. Hodge's view, but if you take such a series as he himself got together for the Newcastle Museum you can show that his rules are not always true and that there are intermediate stages to be found.

A word of warning may be uttered as to the word "*violacea*;" some violet-coloured specimens from Kenmare River which Prof. Haddon was kind enough to send me to assist in this investigation are all forms (and a wonderful variety too) of *A. rubens*. Of specimens with a violet colour I shall have something more to say soon. Here it need only be remarked that Messrs. Koren and Danielssen * are not doing justice to the observations of English naturalists at any rate when they say of *A. rubens* that "it is met with in two varieties of colour, from which there has at different times and by different writers been formed two species, viz. *Asterias rubens* and *A. violacea*."

The next authors whom we need cite are Messrs. Leslie and Herdman, who in 1881 published † a very useful list

* 'Norske Nordhavs Exp., Asteroidea,' p. 24.

† Proc. Roy. Phys. Soc. vi. (1880–81), pp. 90 and 91.

of the Invertebrata of the Firth of Forth. They say of *A. violacea* that they "have often obtained this species or variety in the Firth, and have always been inclined to regard it as a mere variety of the widely distributed and polymorphic *Asterias rubens*. At present, however, we have followed Mr. Norman and Professor Perrier in giving it the rank of a separate species."

The only foreign writer who in recent years has discussed the characters of *A. violacea* with a good faunistic knowledge is, I think, M. Fischer *, who writes under *A. violacea*:—"Hab. Avec l'espèce précédente [i. e. *A. rubens*, which is found on "toutes les côtes de sud-ouest de la France"], dont elle n'est peut-être qu'une variété, ainsi que le supposent Müller et Troschel; néanmoins, sa coloration est constante, ses tubercules sont plus petits, ses bras plus étroits, sa consistance moins charnue," &c. But it cannot, I fear, be said that this is a very satisfactory statement of the specific points.

The very latest mention of *Asterias violacea* which I know is to be found in Mr. Hoyle's paper on the fauna of the Clyde, for which I am, I believe, responsible †. The specimens which I was led to suppose to be *A. violacea* belong, I am now inclined to think, to a distinct species, which I propose to describe immediately.

I was at first in considerable difficulties as to what various authors meant by *A. violacea*. The British Museum collection contains but few specimens of *A. violacea* determined to be such; there is one specimen, connected with which is a label in the handwriting of Prof. E. Forbes, which, if it be not *A. rubens*, is certainly one of the numberless varieties to which reference has just been made. The specimen from Plymouth Sound which, in his 'Catalogue of British Radiata,' Dr. Gray refers to *A. violacea*, is, if I may use the word, certainly *A. rubens* ‡. There is a specimen about which it is very difficult to speak certainly—Dr. Gray registered it as *A. violacea* and labelled it *A. rubens*. And, lastly, there is an example from the Faroe Islands determined probably by Dr. Lütken, which may be safely said to be *A. rubens*, though it is named *A. violacea*.

Not one of these specimens therefore would justify the student in asserting that *A. violacea* is to be distinguished

* Act. Soc. Linn. Bordeaux, xxvii. (1869), p. 365.

† I must beg, however, to add that I do not accept any responsibility for the "distribution" assigned to this "species" and to "*A. rubens*," though I am far from saying that it is not correct.

‡ I may confirm this by a saying of Prof. Stewart that *A. violacea* is not found at Plymouth.

from *A. rubens*. But these specimens of Mr. Murray's to which I refer were of a violet colour and had tapering ambulacra, and I determined them therefore to be *A. violacea*.

As the collection increased, and I may say that the British Museum collection of British *Asterias* is now very extensive, my suspicions were aroused by the fact that from no locality other than West Scotland did Mr. Murray's species appear, and many skilled naturalists to whom I showed it declared that they had never seen it before.

Certainty as to what could really be meant by others when they used the term *A. violacea* was only attained when I had the loan of Canon Norman's specimens and of those collected by Mr. Hodge and preserved in the Newcastle Museum *. When I did so I found that Mr. Hodge's rules do not stand when a large series is taken. Similarly I found that the examination of a large series of starfishes, kindly sent me from the classical Cullercoats by Mr. Richard Howse, revealed the fact that "*A. rubens*" and "*A. violacea*" might be brought up from one spot by one dredge.

It will be noticed that Mr. Hodge's "varieties" come from different localities; I propose to show that very different forms can be taken from one and the same spot. But first we must see what variations there are. Glibly as many of us talk about variation, the figures on Plate XIV. will probably be a revelation to some; these direct attention only to the differences in spinulation, and that appears to be not only the most instructive but also the most important character.

Firstly, and in a general way, it will be observed that there are clearly two types of spines, one flat-headed or blunt, the other sharp at the tip; so, again, the spines may be comparatively few or closely packed, or they may be coarse and strong or fine and delicate (Pl. XIV.).

These facts are so well brought out in the Plate drawn by Mr. Highley that it would be surplusage to dilate upon them.

Now as to the distribution of these various forms, we have the coarsely spined form shown in fig. 8 only from the Shetland Islands; but the spines may be stouter and less sharp than or not so rough and numerous as in the specimen figured in other specimens from the same place, and on the other hand there is a very rough and strongly spined form from 55 fathoms (south-west of Ireland). There is such a

* To the authorities of which I desire to express my thanks for their kindness.

noticeable reduction of the spines in the specimen from Plymouth (fig. 6) that one might be inclined to suppose that spinulation becomes less coarse and more scanty in more southern latitudes, were it not that specimens equally poor in spines can be taken off the west coast of Scotland ; a specimen from Kenmare River is more like that figured from Plymouth than like that shown in fig. 3, which came from the south-west coast of Ireland. Forms with as blunt spines as those from the Seaham specimen (fig. 4) may be taken from the Shetland waters, and such spines may be loosely or closely packed. The specimen (fig. 5) from Cullercoats could be duplicated from St. Andrews. Enough perhaps has been said on the subject of spinulation.

The general appearance of a starfish is, of course, largely affected by the relations of the radius of the disk (r) to the length of the arm (R). Specimens from Kilbrennan Sound show $R=6{\cdot}5\ r$, $R=6\ r$, $R=4{\cdot}5\ r$; from Cullercoats we get $R=5\ r$ or $R=4\ r$; two specimens from Plymouth give $R=5{\cdot}5\ r$ and $R=4\ r$; so here again there is variation without any apparent relation to locality.

Yet, again, the breadth of the arms at the base affects the habit or general contour of the spines, and this too is liable to considerable variation.

Forbes laid particular stress on the form of the ambulacra ; but it will be found that the pyriform lanceolate shape is often associated with a sharp spinulation, and not with the blunter form which is characteristic of "*A. violacea.*"

Some noticeable variations in length and breadth may be seen in the table which follows :—

R. millim.	*r*. millim.	Greatest breadth of arms near base. millim.
210	30	50
178	28	37·5
160	31	32
150	23	35
99	16	22
76	16	22
62	10	15
48	12	19
40	9	11
33	7	8·5

I am brought therefore to the conclusion that *Asterias rubens* and *A. violacea* are not to be distinguished, and I offer the following diagnosis :—

R=7 *r* to 4 *r*.

Arms generally five, rather stout, rounded, tapering very gradually, but not very narrow even at tip *, sometimes quite broad there. Dorsal surface covered with spines, subequal, generally of moderate size, closely packed, moderately numerous or sparse, in form they are pointed or more or less or quite blunt at their tips; a single, often prominent, row, which is either nearly straight or slightly zigzag, and then appearing at times to be double, runs along the middle of the back of each arm. Ambulacra wide, bordered by one or two rows of spines, when the inner is the thinner. A rather well-marked groove separates the outer adambulacral row from the next, which with another forms a pretty regular series along either side of the lower surface of each arm; the outer of these has groups of two or three spines set a little obliquely to the long axis of the arm. Further out there is a wide groove, and at the infero-lateral edge of the arm there is an irregularly double row of spines, which are often the strongest and best-developed of any on the body; sometimes, however, the ventral spines are as strong or stronger. Madreporite rather coarsely striate. A circlet of minor pedicellariæ at the base of the spines; major pedicellariæ † scattered over the

* Except in *A. rubens*, var. *attenuata*.

† I greatly regret to find that, by using them in his 'Challenger' Report, Mr. Sladen has given to Dr. Herapath's names a vogue which they do not deserve. The distinction between "scissors" and "shears" drawn by Mr. Sladen (Journ. Linn. Soc. xiv. (1879) p. 433, footnote) is not recognized either by lexicographers or by less learned persons, as the accompanying citations from the 'Imperial Dictionary' will show. If the connotation could be reversed and the term forcipiform be applied to the "pedicellaires droits" of Perrier and the forficiform to the "pedicellaires croisés" there would be a closer resemblance between the name and the thing named. But such a course is impossible now, and we must, I am afraid, be content with the much less expressive terms "major" and "minor."

"*Forceps*. A general name used for a two-bladed instrument on the principle of pincers or tongs, used for seizing and holding and for extracting objects which it would be impracticable thus to treat with the fingers.

"*Scissors*. A cutting instrument resembling shears, but smaller, consisting of two cutting blades movable on a pin in the centre, by which they are fastened, and which cut from opposite sides against an object placed between them.

"*Shears*. An instrument consisting of two movable blades with bevel edges, used for cutting cloth and other substances by interception between the two blades. Shears differ from scissors chiefly in being larger, and they vary in form according to the different operations they are called upon to perform. The shears used by farriers, sheep-shearers, weavers, &c. are made of a single piece of steel, bent round till the blades meet, which open by themselves by the elasticity of the metal."

arms, varying somewhat in the number to which they are developed.

Colour. Red, orange, or purple.

Distribution. Eastern side of North Atlantic (Senegal to Finmark); Japanese Seas. Presence in Arctic Ocean uncertain, in Mediterranean very doubtful.

A. rubens, var. *attenuata.*

A. rubens, var. *attenuata*, Hodge, Trans. Northumb. and Durham, iv. (1872), p. 137.

Varieties with very slender arms and rare spines are sometimes so well marked that, as I have already indicated, I am inclined to think we may mark the variation by a name. Mr. Murray dredged such a specimen off Tobermory, Mull (30 fath.), and one of the 'Knight Errant' forms dredged off North Rona and described by Mr. Sladen may be put in the same category.

R=105; 75: *r*=15; 13.

Breadth of arm at base 14; 15.

Müller and Troschel accepted the statements of Lamarck and Risso as to the presence of *A. rubens* in the Mediterranean; Prof. Perrier in 1875 spoke of it as "provenant de toutes les mers de l'Europe," and in 1884 Messrs. Koren and Danielssen practically say the same thing; but in 1878 Perrier wrote that it "ne parait pas pénétrer dans notre grande mer intérieure;" it is not given by Professors Sars or Ludwig in their reports on the marine fauna of the Mediterranean, and Carus accepts Perrier's later view.

With regard to the presence of *A. rubens* in the Japanese Seas it is customary (*cf.* Perrier or Koren and Danielssen) to make Dr. v. Martens responsible for the statement that the species is found there; but v. Martens refers to specimens from Japan seen and recorded by Müller and Troschel. Perrier adds, "Jusqu'ici aucun autre fait n'est venu confirmer cette affirmation." Almost contemporaneously, however, Mr. Sladen recorded *A. rubens*, var. *migratum*, from the Korean Straits*.

The question arises therefore as to the circumpolar distribution of the species; Wagner and Jarzynsky report it from the White Sea, but it is not to be found in Levinsen's list of Echinoderms from the Kara Sea; Sabine reports it from Davis Strait, but Duncan and Sladen do not give it among the Greenland Echinoderms. On this point it seems to be

* I cannot find any reference to this form in Mr. Sladen's 'Challenger' Report.

necessary to reserve our judgment. It is, however, clear that on the Atlantic shores of Northern Palæogæa *A. rubens* is widely distributed.

On the western shores of Scotland there is a form present which, so far as I know, is confined to that area of the Clyde. Mr. Sladen is the only naturalist I know of who has specimens other than those collected by Mr. John Murray, and although Prof. Haddon thinks he has taken it off the south-west coast of Ireland, the specimens he has been so kind as to let me see appear to be merely *A. rubens*.

This form I propose to call *Asterias Murrayi*, as an indication of the sense of gratitude I feel to Dr. John Murray for the valuable collections made by him off the west coast of Scotland and presented to the British Museum.

Asterias Murrayi. (Pl. XV.)

R=7 *r*.

Arms and disk flattened, the shallow sides nearly vertical, disk small. Arms slender, with somewhat constricted bases. Ambulacra wide, feebly constricted at base, but otherwise tapering regularly; the ordinary arrangement of the adambulacral spines is the alternate disposal of one and two on successive plates. On the outer side of the shallow groove that bounds the spines is an irregular set of spines, which, where most orderly, are arranged in two longitudinal rows; sometimes they are grouped in threes and the set is placed transversely to the long axis. The side of the arms is bare of spines; along its upper edge is a single row of spines; this never seems to be doubled. At first sight a large specimen may seem to have no other spines on its dorsal surface but a faintly indicated row along the middle line, and neither optical nor tactile examination will reveal many more, save just a few on and about the disk. The whole surface will, however, be found to be densely covered with pedicellariæ; on smaller specimens there are a larger number of small spines on the arms, but they are never numerous. Madreporite large, distinct, quite close to margin of disk.

Colour. Violet or greyish white, darker when dried, lighter when preserved in spirit.

Hab. West coast of Scotland (Upper Loch Fyne, 65 fath.; Loch Goil, 45 fath.; mouth of Kilbrennan Sound, 22 fath.).

R 173; 97 : *r*=24; 14.

It is very interesting to observe that in comparatively young specimens the general appearance is very much more that of *A. rubens* than is the case with the adult. The arms

are a little swollen and puffed near the base and the reduction of the dorsal spines is not so marked. It is very probable that this, if a "new species," is one not only in the corresponding French sense of "inedit," but even in the evolutionary sense of the word.

We appear to be justified in regarding this species as distinct on account of the constancy of its slate-grey or violet colour, its flat arms, more slender than in *A. rubens* (except the variety *attenuata*, in which the rounded arm-form of *A. rubens* is retained), its loss of dorsal spines, and its limited geographical range.

I am not acquainted with any additions that have been made to our knowledge of the characters of *A. hispida* since 1881, when I published (Proc. Zool. Soc. Lond.) what information and criticism I could get together on the species.

It was then found that R may be no more than twice *r*, that the adambulacral spinulation is constantly monacanthid, and that the major pedicellariæ are absent. The combination of these three characters may well be regarded as diagnostic of a species, and such forms as present it may be called *A. hispida*.

EXPLANATION OF THE PLATES.

Plate XIV.

Figures to illustrate some of the variations in spinulation seen on the back of *Asterias rubens*.

Fig. 1. Spines rather blunt, thickly scattered over the whole surface. From Aberdeen.

Fig. 2. Spines blunt, with flat or rounded, not sharp tips, not at all unlike fig. 4. From Tenby, low water.

Fig. 3. Blunt spines, more reduced than in fig. 2. South-west Ireland.

Fig. 4. A specimen sent by Dr. Norman as an example of *A. violacea*; compare with fig. 2. From Seaham.

Fig. 5. Spines more reduced than in fig. 3, but of the same type. From Cullercoats.

Fig. 6. Spines larger than in fig. 5, but rarer, sharp at their tips. From Plymouth.

Fig. 7. Spines much sharper, rather stronger and rather less numerous than in an ordinary *A. rubens*. From Aberdeen.

Fig. 8. Of the same character as fig. 7, but more pronounced; spines a good deal stronger than usual. From Shetland.

Fig. 9. A very finely developed specimen from Kilbrennan Sound.

All of the natural size.

Plate XV.

Fig. 1. *Asterias Murrayi*, natural size. Figure to show the general habit of this starfish, its flat arms constricted at their base, and the rare scattered spines.

Fig. 2. Part of upper surface of arm, natural size.

Fig. 3. Part of lower surface of arm, natural size.